TURBODEN
BIOMASS

ORC COGENERATION SYSTEM FROM YOUR GREEN FUEL.
LEADER IN BIOMASS SINCE 1980

Since its foundation Turboden has been committed to delivering efficient and reliable cogeneration solutions from renewable sources.
Turboden Organic Rankine Cycle (ORC) plants produce electric power and heat with high efficiency and automatic operation by using any kind of biomass, from virgin wood to organic residues from various production processes.

**KEY POINTS**

- Large range size up to 20 MWe per single shaft
- Generate profit by valorizing a renewable source
- Provide a reliable source of power also for island mode operation
- Reduce specific production cost by decreasing energy demand
- Improve company sustainability
- Reduce CO\(_2\) emissions
TURBODEN BIOMASS UNIT DESIGN

CHP SOLUTIONS (low and high temperature cogeneration)

Turboden units generate Combined Heat and Power (CHP) solution - providing either hot water or higher temperature heat medium (e.g. saturated steam or thermal oil). Alternatively Turboden can provide also electric power only solutions.

<table>
<thead>
<tr>
<th></th>
<th>POWER-ONLY</th>
<th>CHP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical</td>
<td>up to</td>
<td>up to</td>
</tr>
<tr>
<td>efficiency</td>
<td>30%</td>
<td>22%</td>
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THE ORC CYCLE – HOW IT WORKS

The ORC turbogenerator uses medium-to-high temperature thermal oil to preheat and vaporize a suitable organic working fluid in the evaporator (4>5).

The organic fluid vapor rotates the turbine (5>6), which is directly coupled to the electric generator, resulting in clean, reliable electric power.

The exhaust vapor flows through the regenerator (6>7), where it heats the organic liquid (2>3) and is then condensed in the condenser and cooled by the cooling circuit (7>8>1).

The organic working fluid is then pumped (1>2) into the regenerator and evaporator, thus completing the closed-cycle operation.
EXAMPLE OF A BIOMASS PLANT WITH ORC SYSTEM

HEAT TRANSFER FLUID

The heat from biomass combustion is transferred to the ORC working fluid by means of an intermediate circuit or directly via the combustion gases in direct exchange systems. The media used in the intermediate circuits are thermal oil, saturated steam or superheated water.

*In alternative to more traditional combustion systems, gasification and pyrolysis solutions may be applied.
THREE MAIN POSSIBLE SCHEMES

- **POWER ONLY**
  - Electric power**: 25-30%
  - Thermal power dissipated 70-75%
  - 2% losses

- **CHP HOT WATER**
  - Electric power***: 16-22%
  - Thermal power 78% (hot water up to 120 °C)
  - 2% losses

- **CHP STEAM**
  - Electric power***: 15-18%
  - Thermal power 82% (steam 5÷30 Bar or thermal oil)
  - 2% losses

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**FUEL ENERGY INPUT**

- 100%

**ORC**

- 15% losses

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* Depending on fuel and boiler features

** Depending on size and environmental temperature

*** Depending on heat output temperature

**Biomass**
KEY FACTORS FOR SUCCESS

FUEL AVAILABILITY AT AN AFFORDABLE COST IN THE LONG RUN MINIMIZING TRANSPORT COSTS

A HEAT USER TO VALORIZE THE CO-GENERATED HEAT (CHP configuration is more efficient and remunerative than a power-only one)

SUCCESSFUL BIOMASS PROJECT

HIGH ENERGY VALUE (renewable incentives, PPA, feed-in tariffs, green certificates, etc.) AND RELIABLE SOURCE OF ELECTRICITY IN ISLAND MODE SYSTEMS
APPLICATIONS

- sawmill residues or by-products
- bark
- wood dust and chips
- pellet
- furniture waste
- particle board screen dust
- recycled wood waste
- olive pomace and pits
- bruning & trimmings
- barley dust
- malt dust
- rice husks
- almond shells
- sunflower husks
- coffee husks and spent ground
- corn cobs
- coconut shells and husks
- empty fruit bunches
- palm kernel shells
- cotton gin waste, stalks
- paper

HEAT USERS

- TRIGENERATION*
- FOOD
- RICE
- PELLET
- SAWMILL
- DRYING
- DISTRICT HEATING
- FISH FARMING
- GREENHOUSE
- WATER
- 50°C (low temperature)
- 130°C
- 200°C (high temperature)
- STEAM
- MALT PRODUCTION
- MDF/Plywood
- Synthetic Fibers
- Beer
- Chemical Processes
- Pulp & Paper
- Dairy
- Vegetables Oils Refining
- Laundry and Ironing Workshops

* with absorption chiller.
# EXAMPLES OF SUCCESSFUL PROJECTS

<table>
<thead>
<tr>
<th>SAWMILL, WOOD-BASED PANEL</th>
<th>RICE, CEREALS, FOOD PROCESSING</th>
<th>DISTRICT HEATING</th>
<th>PELLET AND CHARCOAL PROD.</th>
<th>POWER ONLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>84 plants</td>
<td>7 plants</td>
<td>165 plants</td>
<td>41 plants</td>
<td>19 plants</td>
</tr>
</tbody>
</table>

**Fuel**
- Wood residues (e.g. bark, sawdust, etc.) from sawmill production process.
- Rice husks, corn cobs, recovered locally from the rice/cereals processing industry.
- Various depending on geographical area (typically wood chips).
- Wood residues (e.g. bark, sawdust, etc.) from pellet and charcoal production process.
- Various depending on geographical area.

**Power**
- Used to feed internal auxiliaries; it can also be used to sustain island operation.
- Used to feed internal auxiliaries; it can also be used to sustain island operation.
- Incentives as a renewable source. Also used partly to power internal users.
- Used to feed internal auxiliaries.
- Incentives as a renewable source.

**Heat**
- Fully used in drying chambers as hot water or low-pressure steam.
- Used for rice processing as hot water or steam, cereal drying.
- Used to feed the heating network.
- Used as hot water for wood drying in the process.
- No use.

**Note**
- Fuel generated as by-product by the industry, heat and electricity valorized internally by the same industry.
- Fuel produced as by-product by the facility, heat and electricity valorized internally by the same industry.
- Fuel collected from various sources, heat sold to the local district heating network, electricity partly used internally, and the rest sold to the grid.
- Fuel generated as by-product by the facility, heat and electricity valorized internally by the same industry.
- Fuel collected from various sources, electricity sold to the grid. Business model viability subject to biomass price fluctuation.
CHP IN WOOD INDUSTRY

CUSTOMER: Stia Holzindustrie
COUNTRY: Austria
STATUS: in operation since 1999
ORC SIZE: 0.5 MWe
DESCRIPTION: CHP in a wood factory (wooden flooring and panels)
FUEL: wood residues
HEAT CARRIER: thermal oil
WATER TEMPERATURE (IN/OUT): 60 - 90 °C

Longest Turboden ORC in operation
More than 80 plants integrated with wood industries
POWER GENERATION IN SAWMILL

CUSTOMER: West Fraser Mills
COUNTRY: Canada
STATUS: in operation since 2014 – 2015
ORC SIZE: 26 MWe (4 x 6.5 MWe)
DESCRIPTION: power only in two large sawmills
FUEL: residues from sawmill process (mainly bark)
HEAT CARRIER: thermal oil
WATER TEMPERATURE (IN/OUT): 24 - 34°C

The largest lumber producer in North America

More than 80 plants for sawmills worldwide
CUSTOMER: Athens Energy
COUNTRY: United States of America
STATUS: in operation since October 2016
ORC SIZE: 8 MWe
DESCRIPTION: power only in a wood pellet factory
FUEL: virgin wood
HEAT CARRIER: thermal oil
WATER TEMPERATURE (IN/OUT): 25 - 33 °C
CHP IN WOOD-BASED PANEL INDUSTRY

CUSTOMER:  
Starwood

COUNTRY:  
Turkey

STATUS:  
in operation since October 2016

ORC SIZE:  
5.5 MWe

DESCRIPTION:  
CHP in an MDF panels factory

FUEL:  
panels residues and wood waste

HEAT CARRIER:  
thermal oil

WATER TEMPERATURE (IN/OUT):  
90 - 110 °C

ADDITIONAL FEATURES:  
ORC turbine locally produced by Turboden Turkey

Around 10 plants (CHP and power only solutions)

Tailored solutions for MDF, particle board, plywood factories, etc.
CHP FOR DISTRICT HEATING NETWORK

CUSTOMER: Fernheizwerk Toblach-Innichen
COUNTRY: Italy
STATUS: in operation since December 2003
ORC SIZE: 1.5 MWe
DESCRIPTION: CHP for the district heating network
FUEL: wood chips
HEAT CARRIER: thermal oil
WATER TEMPERATURE (IN/OUT): 60 - 80 °C

Renewable energy for houses heating

165 total plants for district heating
CUSTOMER: Rice Hull

COUNTRY: California, USA

STATUS: Under construction, expected start-up 2021

ORC SIZE: 3.6 MWe

DESCRIPTION: Electric power only with air cooled condenser (no water consumption)

FUEL: rice husk

HEAT CARRIER: thermal oil

POWER GENERATION IN AGRO FOOD INDUSTRY

Different kind of fuels: rice, cereal, production waste, etc.

Profitable management of agro residues
POWER GENERATION IN AGRO FOOD INDUSTRY

CUSTOMER:
Sobono

COUNTRY:
The Philippines

STATUS:
in operation since December 2017

ORC SIZE:
5.5 MWe

DESCRIPTION:
CHP in a farm for cereals dryers

FUEL:
rice husk

HEAT CARRIER:
thermal oil

WATER TEMPERATURE (IN/OUT):
40 - 80 °C

Efficient exploiting of different kind of waste

Island mode operation
SELECTED CUSTOMERS
OUR EXPERIENCE. YOUR POWER.

FIND OUR MORE

[Icons for website, YouTube, Instagram, LinkedIn]